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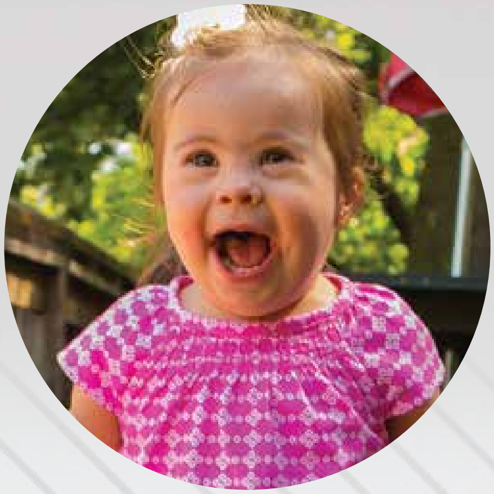
Surestep SMOs

An Optimal Solution for Pediatric Flexible Flatfoot

By Megan Smith, Certified Orthotist
Former Surestep Director of Clinical Research



The literature is in agreement on treating pediatric flexible flatfoot when it is symptomatic[1,2]; however, the symptoms listed may not be complete. It is also unclear as to which treatment solution(s) are most appropriate for this patient population. This letter is aimed to describe flexible flatfoot, its side effects and appropriate treatment solutions.

Children with hypotonia, or low muscle tone (regardless of underlying diagnosis), often present with bilateral flexible flatfoot. While flatfoot, or pronation, is typical in infants and young children, excessive pronation can lead to developmental and gait deficits. There are many supporting reasons for the need to treat pediatric flexible flat foot no matter the child's age. These include bone development, postural control development and variability, proprioceptive input, gross motor skill development and gait maturation.

Pronation

Pronation is a term used to describe a triplanar movement of the foot and ankle complex. It is comprised of calcaneal valgus, collapse of the medial longitudinal arch and forefoot abduction. The biomechanical effects of pronation are not isolated to the foot and ankle. As the effects work their way up the closed chain, they can be seen throughout the entire lower extremity. Normal pronation in infants is determined by the amount of calcaneal valgus present. Children with hypotonia oftentimes present with significantly more calcaneal valgus than what is considered typical. In his equation, Valmassy states that the amount of calcaneal valgus during static weight bearing should be equal to 7 minus the child's age and should be vertical by 7 or 8 years of age[3]. Therefore, a 2 year old child should present with approximately 5 degrees of calcaneal valgus.

"The biomechanical effects of pronation are not isolated to the foot and ankle."

During normal gait, the calcaneus passes through the vertical position twice during each stance phase[4]. This position, also called subtalar neutral, should not be a static position in which to hold a mobile foot and ankle complex. Orthoses should minimize excessive pronation movements and restore normal subtalar motions within a normal range of motion.

Hypotonia

Hypotonia is described as a lack of resistance to passive stretch. Children with hypotonia can be described as "floppy" and exhibit an increased range of motion, as we oftentimes see children with hypotonia also present with ligamentous laxity. It has been described in the literature that children with hypotonia are also weak[5]; however, there is some controversy to this statement. Strength is defined as the ability of a muscle to exert a force on an object and can be increased through strength training. It is determined by the cross-sectional area of muscle fibers recruited to generate a force and the intensity of the recruitment. Muscle tone is an intrinsic property of the nervous system and is controlled by the stretch reflex which is regulated by muscle spindles. In hypotonic muscles, the spindles are not pulled as taut, and therefore require a greater stretch of the muscle before they are activated. This delays the signals to the brain that synapse on alpha motor neurons and cause the muscle to contract. This delay in muscle activation can appear as weakness; however, when put in optimal alignment, the timing of the contraction is more typical and the strength of the underlying muscle is revealed. Therefore, hypotonic muscles may just be delayed in the timing of contractions and may not actually be weak. Our goal should be to optimize the position of the muscles and tautness of the spindles to optimize the child's strength and improve timing of the muscle contractions.

Bone Development

Ossification is a term used to describe the process of bone formation. It begins in utero and is not complete in all bones until early adulthood. All bones ossify at different ages and at different rates. In the foot and ankle, the supporting structures are not fully ossified until after the age of 7[6-9]. Bone growth is affected by Wolff's Law, which states that bones grow based on the forces directed upon them. Those forces can be gravitation and/or from the pull of soft tissue, such as muscle. When the forces of muscles are applied appropriately, proper bone formation is expected. However, when muscles are operating in suboptimal alignment, the forces they apply to bones direct growth in atypical directions. If the bones in the foot are allowed to ossify in a pronated position, the child will continue to pronate into adulthood due to bony foot structure[10]. When treating children with hypotonia and flexible flatfoot, orthotic solutions should aim to keep the foot and ankle in more proper alignment and allow more appropriate forces (muscle and gravity) on the bony structure. This may affect bone development through the stages of ossification and prevent foot deformities as the child ages.

***Figure 1**. Triplanar position of an excessively pronated foot*

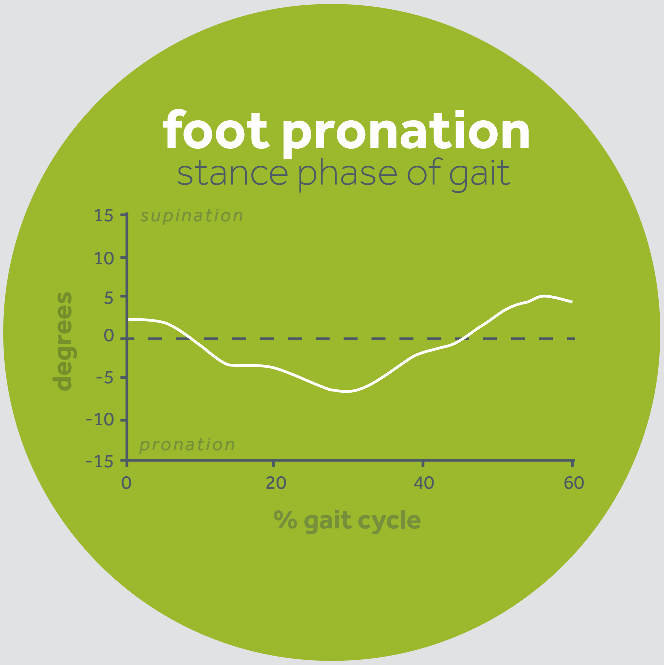


Figure 2. *Normal subtalar neutral motion during stance phase of gait.*

Postural Control and Variability

The goal of postural control is to maintain balance, or maintain center of gravity within the base of support. Postural control begins to develop in infancy and continues into adolescence[11-14]. Variability is a key component to postural control development. As a child is developing and learning a new skill, he or she should be utilizing a variety of motor strategies to accomplish that goal or task. Children with hypotonia oftentimes lack complexity or variability in motor strategies. This can lead to a decreased ability to adapt to the world around them. For example, a child who is significantly pronated while walking does not have the ability to supinate during stance phase. This child has no variability, or choices, in foot position. If he or she were to attempt to walk on an uneven surface that required supination, we would most likely observe the child fail to traverse the terrain successfully. On the other hand, some children present with too much variability and cannot correctly choose the appropriate solution. With these children, we need tools, including orthoses, to narrow their choices in motor strategies. We live in an environment that is ever-changing and evolving and our solutions need to allow our children to build an appropriate repertoire of motor strategies and movement patterns in order to be successful.

Proprioception

Another deficit we typically see associated with children who present with hypotonia is a lack of proprioception, or body-awareness. Proprioception describes the ability for the body to sense itself in space. Children who lack proprioception can be labeled clumsy or uncoordinated. They do not have an accurate sense of where their feet are underneath them. Combine that with the poor position of the pronated feet, poor timing and alignment of muscle activation due to hypotonia and these children are more susceptible to developmental delays.

Gross Motor Skill Development

Children with hypotonia and excessive pronation are frequently delayed in gross motor skill development. The delay may be seen as early as sitting, or may become more apparent when pulling to stand and then taking independent steps. It is common to see these children be mildly delayed when they start to pull to stand and cruise, then plateau, or "get stuck", and do not progress past that milestone as quickly as their peers and subsequently become more significantly behind in walking age. This further delay in walking is due to an unstable base of support, lack of postural control development and a lack of appropriate proprioception. Our treatment solutions should aim to restore those deficits in order to keep the child on track developmentally with his or her peers.

"Postural control begins to develop in infancy and continues into adolescence"

Gait

If a child presents with hypotonia and associated flexible flatfoot, we will oftentimes see that he or she stays pronated throughout the gait cycle. Due to the excessive calcaneal valgus, hypotonia and associated poor muscle timing and alignment, the child is not able to pull the foot out of the pronated position for weight acceptance or push off. In older children, excessive pronation can also diminish the effects of the swing limb torque generator and reduce the ability of the swing limb to get to full knee extension. A lack of full knee extension in terminal swing effects the position of the foot and ankle at initial contact. This poor position of the lower extremity at initial contact has ramifications on position and energy efficiency throughout stance phase. In our treatment of flexible flat foot, we should aim to provide solutions that promote both normal pronation and supination, allowing more typical gait development.

Treatment

Surestep SMOs (Supramalleolar Orthoses)[15] aim to address all of these issues that are commonly seen in children with hypotonia and associated flexible flat foot. The SMO is made of a thin, flexible plastic that works through compression to provide dynamic stability in and out of midline. With the SMOs, children are able to pronate and supinate within normal limits which allows them to operate and learn gross motor skills in optimal alignment. This is a desirable solution for these patients because they do not become dependent on the SMOs, and can work on developing dynamic control of their foot and ankle positions. The Surestep SMO does not hold the foot and ankle in subtalar neutral, but rather facilitates normal pronation and supination. By grabbing ahold of the calcaneus, and not just pushing up on the arch, the SMO better controls the flexible flat foot and may help the bones of the foot and ankle ossify in more optimal alignment. This can help the child avoid an excessively pronated foot as he/she matures and avoid future associated issues, such as knee, hip and back pain. The SMOs can help introduce variability to children who lack it, but also limit excessive movement or variability in children who present with too much. Because they work through compression, the Surestep SMOs provide proprioceptive input to the foot and ankle. This can improve sensory input and may also promote better muscle timing through mechanoreceptor activation, allowing the hypotonic muscle to react more quickly. The trimlines of the SMO are also unique and designed to reduce excessive pronation and facilitate natural development of motor skills and gait. The lateral trimline is just distal to the 5th metatarsal head, which helps control forefoot abduction and the medial trimline is proximal to the 1st met head. The combination of these trimlines ensures that the child's toes are free to run, jump and play. This also helps facilitate proper gait mechanics, including development of the 3rd rocker and therefore, the arch through the windlass mechanism. Once all of these inputs are restored, the child who is developmentally delayed can progress almost twice as fast as their typically developing peers, and in turn, catch up to their peers with gross motor skills[16,17]. Surestep SMOs have also been shown to improve gross motor skills, both immediately and long term[18], for children with Down syndrome and were preferred when compared with Cascade DAFO4 SMO[19].

Figure 3. *Surestep SMOs*

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